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Kathryn D. Sullivan, Ph.D.
Under Secretary of Commerce for Oceans and Atmosphere
and NOAA Administrator

Thank you, Carol, for that very nice introduction. It’s the common parlance around the NOAA team; one other point of my space career is that Sandra Bullock played me in the movie.

It’s been a long time since I attended an AGU meeting. I was trying to remember quite when it was. The most memorable one was where I ducked out of thesis defense preparation to attend in Miami a hundred years ago right before I defended my own Ph.D. It was a large meeting then and it has grown into a spectacularly large assembly now. So kudos to everyone who’s leading the Union and carrying it forward.

Before I get started on my topic today, I want to give a shout-out to several of my NOAA colleagues for recent honors and distinctions they've received from the union: Mike McPhaden, who served as AGU President from 2010 to 2013 and David Parrish who is one of this year's AGU Fellows. We are very proud of both of them, and very grateful to have them on the NOAA team. And in addition, AGU has given its Ambassador Award to Jim Overland, as well as to David Rust, who’s retired from NOAA and also became a Fellow this year. So it’s great to be part of a team that’s got those sort of fabulous talents on it.

And I want to add some kudos to the union as well for the new multidisciplinary and open access online journal, *Earth and Space Sciences*. It’s great to see a leading professional society putting free and open access to data and research results into practice. This is what it takes to allow everybody to innovate freely and accelerate improving our understanding of the Earth-system.

Open access to data and public access to research results, as you all know, are also priorities of the Obama administration and, of course, in the open data arena. one of the central tenets of NOAA operations for decades.

So my talk today is about making communities more resilient. This is a central challenge of our times, and it’s one of NOAA's top priorities. What I want to do today is share our strategy, give you a glimpse of some of our major initiatives, and touch on some of the key science challenges that we need people like you to tackle. I'll save a little bit of time towards the end of my remarks to announce an exciting new open-innovation challenge for environmental sensing that is launching today.

So, why RESILIENCE?

A growing body of evidence makes clear that Earth's climate is changing in ways that are not consistent with natural variability and forcing. The principal cause of this, as people in this room know well, is the buildup of carbon dioxide and other heat-trapping gases in our atmosphere, due to fossil fuel usage and land-use change. Harmful impacts of this are already being felt in the United States and other nations.

And there are really only three courses of action open to us as we face these circumstances:

> The first is to MITIGATE further build-up of gases to avert the worst possible consequences,
>
> The second is to ADAPT and become RESILIENT to the consequences that are already locked in and inevitable,
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> And the third is simply to SUFFER the environmental, social and economic disruptions that will ensue from this unrivaled change.

This simple stark reality is why resilience is a major pillar of the Climate Action Plan that President Obama released in June 2013.

Now, "resilience" is a pretty broad concept, and the word is used differently by various players in the environmental arena. So I want to clarify what NOAA means by “resilience,” and how we see our role in this endeavor.

The dictionary definition of “resilience” is ***springing back***, ***rebounding***; the ***ability to recover original form or function after disruption or misfortune***.

And that's basically how we mean it at NOAA, but with an important addendum: When NOAA says “resilience,” we always mean the three elements you see on the screen. Resilience in the domains we work, and the problems we help society to address, always has **Societal,** **Economic** and **Ecological** dimensions, and these are always intertwined inextricably.

And how does NOAA fit into this? We are a science-based services agency; I like to think of us as America’s Environmental Intelligence agency. Environmental Intelligence is at the core of what we do, across our full mission span. We are nothing without the great science and vital observations NOAA is famous for, don’t get me wrong, but our central **PURPOSE, I think,** is to transform these into Environmental Intelligence.

And just what do I mean by that? Reliable, timely, actionable, science-based information that can guide action and inform decisions. Producing Environmental Intelligence requires observations--real time current observations, calibrated and validated observations--melded with sophisticated earth systems knowledge and modeling methods developed through decades of research. To be useful and to be used, it also requires effective communication, and that in turn requires rich understanding of society, and of human beings, including factors such as how we perceive risk, what kinds of behaviors are triggered in people when they confront risks; modes of communication; and effective decision-making frameworks.

Much of the Environmental Intelligence NOAA provides is PREDICTIVE, and that's a really important point. Practical prediction, the kind that NOAA does, gives us FORESIGHT, and allows us to think ahead; to assess alternative courses of action; possible future outcomes, to plan and prepare and take timely steps to protect life, property and livelihoods.

The canonical example of this is your daily weather forecast, but hazardous weather events make the value of such foresight even more vividly apparent.

So think back to Hurricane Sandy, just over two years ago.

10 days out - NOAA's National Hurricane Center first flagged a tropical system developing off the coast of Africa.

7 days out, the first cues emerged in the European Center's model that Sandy would take a very unusual path. Within 48 hours of that first indication, the models that our National Center for Environmental Prediction confirmed a "left hook" was coming that would jeopardize the most densely populated area in our country.

We turned to and launched twice as many radiosondes at every weather station from Seattle to San Juan, Puerto Rico, because we knew that added data would help improve the maximum certainty to the general public and to emergency officials through our forecasts. I remember being hugely glad that we had our Suomi-NPP satellite in orbit and that our dual-polarization upgrades had gone live on most of the NEXRAD radar network.

But I also remember looking at early storm surge analyses that showed 11 feet of water in lower Manhattan, and realizing that New York and New Jersey were in for catastrophic flooding that would disrupt lifelines and the very fabric of that urban region.

Our Sandy forecasts - our Environmental Intelligence products - gave the advance warning that was needed to prepare, to protect infrastructure and to pre-position first responders and recovery assets.

Emergency operations centers were activated in all the affected states early. Some counties issued pre-emptive disaster declarations, to allow rapid flow of financial aid once the storm had passed.

FEMA activated and pre-positioned their response crews and also their private sector supply chain partners. They had enough lead time and certainty to prepare New York, New Jersey, and Connecticut, and correspondingly they had enough clarity and confidence in our environmental intelligence products to know where they did not have to worry about it and did not have to close businesses in affected communities.

Utility power crews from as far away as Texas began to mobilize in the region days BEFORE the storm hit. And of course, as we all watched, New York City shut down the subway system and moved their transit buses to higher ground to secure those assets.

At NOAA we were preparing, too, because we do much more than just predict the weather in an event like this. Our National Ocean Service, for example, pre-positioned Navigation Response Teams and readied our hydrographic vessels so that we could begin the charting needed to open the ports and harbors soon after the storm passed, and allowed the flow of commerce and the lifeline of the economy to get going again, and support the emergency response efforts. You may remember the famous fuel supply in the Rockaways that was critical to emergency responders that continued to drive through that region. That was thanks to NOAA charting and NOAA vessels.

Most importantly, and the greatest value and consequence of this Environmental Intelligence is that thousands of people got out of harm’s way before the storm hit.

In all of these instances, people acted because they had CONFIDENCE in the source of the information and COMPREHENSION of the hazards and warnings. That confidence is built on the proven quality of our observations, our models, and our forecasting skills. And those are underpinned by literally decades of both scientific ***research*** AND the ***relationships*** our people have with emergency managers, with decision makers in the field and with our partners in the private sector weather enterprise.

The RESILIENCE aspect of the Sandy story becomes clearer when you compare how the nation and affected communities prepared for, responded to and rebounded from Sandy with what happened after Hurricane Andrew in 1992 or Hurricane Katrina in 2005.

As NOAA Chief Scientist, I walked the ground in south Dade County soon after Hurricane Andrew passed over in 1992. More than 125,000 homes were damaged or destroyed in the Miami-Dade region and 175,000 people were left homeless across Florida. The scale of physical devastation and infrastructure damage that storm brought was just mind-boggling.

The post-disaster response was slow and not well coordinated. And the upshot of that was a huge diaspora occurred that hollowed out whole communities - communities that only began some rebound a decade later, when the Florida economy began to heat up again.

And New Orleans, of course, saw a similarly large exodus after Katrina. More than a million and a half million people were driven from their homes in that storm. Many fled to the adjacent states, but Katrina sent refugees to all 50 states in the United States. Today, nearly a decade later, tens of thousands of those people remain displaced, probably never ever to ready to the communities and businesses that they had before the storm.

Hurricane Sandy shifted the nation's thinking about natural hazards, especially weather and climate related ones in some important ways. The focus changed from what response would be needed ***IF*** another event hit, to how to prepare for ***WHEN*** the next one came. From ***"BUILDING BACK"*** to what was in place before an event to ***"BUILDING FORWARD"*** so that we're increasingly ready for the different risk posture, the different threats that we will face in a changing world in the future.

During the year that I served as Acting Administrator, one of the things I did very intentionally was travel around and meet with our customers, the real world users of our Environmental Intelligence, from emergency managers to fisheries councils, state &

federal agency partners, to better understand their needs and get their input on our work.

And I visited NOAA's labs, forecast offices and service centers to hear from our own folks about the needs, opportunities and challenges they saw.

That listening tour led to the identification of four priorities that we will pursue during my tenure as Administrator. As you see, RESILIENCE is front and center. More specifically, our priority is "to provide the information and services that help communities become more resilient."

Now again, that's still a pretty broad landscape, so zooming in, this slide shows the three most prominent domains that the bulk of our work is focused in.

For example: In the coastal arena, we've developed green infrastructure building standards to foster greater use of natural defenses - such as wetlands, marshes and dunes - to protect communities and simultaneously provide greater environmental benefits. Via the President's post-Sandy Task Force, we're working to fold these into the federal government's capital investments in highways, housing, and other infrastructure, again incentivizing and enabling the building forward to our resilient infrastructure that's better able to handle the changes we will see in a future world.

I'll give some examples shortly of some of the work we're doing to improve resilience in the water and coastal domains as well.

I'm going to switch gears now and I want to talk a bit about some of the scientific challenges that need to be overcome to advance these priorities and provide the services. These are challenges that our workforce and our partners find massively compelling and fascinating, and I hope will inspire many of you in this room to join us in this work.

Bridge the Climate-Weather Gap

So the first one is How do we bridge the weather-climate gap? Skillful predictions in the domain that are currently not really tractable at appropriate time and space scales would have tremendous value to society. There are major unmet decision-support needs in the 3 to 8 week range, for example surrounding heat waves and the public health hazard they represent, and the further ones in the 5 to 10 year range, for water managers, for example.

What will it take to bridge the gap between the initial values problem of the weather domain and the boundary conditions problem of the climate domain?

Well, it will take a variety of things, of course. It will certainly take additional observations. We need to identify, develop, deploy and operate the appropriate new systems.

It will take more research to identify the sources of predictability and improve predictive skill; to better understand and model phenomena such as equatorial waves and currents; arctic and tropical processes; the ocean mixed layer; surface momentum and moisture fluxes and aerosols, just to name several.

It will certainly require new coupled data assimilation and analysis techniques, and improved models and more comprehensive earth system models that include the biological and ecological dimensions, as well as the physical dimensions of earth systems.

It will again take operational implementation of a targeted set of these new forecast and information products. And the infrastructure – computational and organizational – that's necessary to sustain PRACTICAL PREDICTION.

The President announced a new initiative aimed at meeting this challenge at the UN Climate Summit in New York this past September, and NOAA is leading this coordinated national effort.

Our initial target is to develop new extreme-weather outlooks in the 15 to 30 day range. Heat, cold and flood extremes are of special interest in this range because of their societal impact.

We are also exploring the production of extreme weather outlooks even further out into the climate prediction scale – monthly and seasonal. For example, forecasting a heat wave a month in advance and being able to depict that graphically on our monthly forecast map. This would also be possible for cold outbreaks, extreme precipitation events, and droughts. We haven't chose these targets out of a hat--we've chosen them after consultation with emergency managers and civic leaders who've identified the sweet spots where better information for them would enable their community to better prepared and better weather the coming circumstances.

So getting even more specific, this year NOAA will begin to issue weekly 3 to 4 week precipitation outlooks. We will extend the current extreme-heat index product from 6 to 10-days to the 8- to 14-day range. And again, here we know from working with emergency managers that a seemingly small number of additional days will make a real difference in your ability to prepare your community to stand up and get non-governmental organizations and civic organizations activated in the face of life-threatening heat waves.

Improve Water Prediction

Another challenge is improving water prediction. Water supply, quality, and variability are increasingly recognized as one of the main challenges facing global society in the 21st century, as this array of headlines attests.

Recognition of the threat this poses has spread to the national security arena. A recent National Intelligence Council analysis determined that many countries important to the United States will experience water problems within this decade and that these will risk instability and state failure, increase regional tensions, and distract those nations from working with the United States on important U.S. policy objectives.

Further, that water problems will hinder the availability of key countries to produce food and generate energy, which in turn will pose a risk to global food markets and hobble economic growth.

Between now and 2040, this report demonstrates clearly, fresh water availability will not keep up with demand without more effective management of water resources. And if you want to ask where is this really an issue, this National Intelligence Estimate points out specific hazards and threats for North America, North Africa, the Middle East and Asia – in other words, the entire populated globe - as regions that will face major challenges coping with water problems.

It's important to remember the big picture here: ***Only ½ of 1% of Earth's total water*** is available for human use--one half of one percent--and that meager bit is increasingly strained by growing populations, increasing pollution, land-use changes, and the greater variability caused by a changing climate.

The water challenge is pretty simple to sum up: ***too much, too little, in the wrong place, of the wrong quality***. That is fast becoming harder for society to handle. As is apparent today and has been in events throughout history, these factors have a substantial influence on civilization, affecting the economy, energy production and use, human health, transportation, agriculture, natural ecosystems--you name it.

Reducing these water-related risks will require more effective management, and better Environmental Intelligence about water would go a long way to fostering this.

And so at NOAA, we're focused on this central societal need, to improve water predictions to reduce uncertainty about availability, quantity, and quality of water resources.

We've translated this into a goal of developing the ability to give a region or community a **total water** picture. And we'll have to overcome quite a number of scientific challenges to get there.

Today we predict water levels at some 4,000 discrete locations nationwide – locations where we have stream gauges. To deliver TOTAL WATER predictions or outlooks, we'll need to be able to predict surface and ground water availability in all watersheds, and water flow and depth in all rivers. We'll have to understand and seamlessly predict the full range of hydrologic extremes, from floods to droughts and short-term to long-term, and understand how they're related to climate, land and water management practices and other drivers.

This is going to take integrated modeling on scales we don't currently do, including models, ensembles, and computational capabilities that can produce outlooks in time ranges between the weather and climate gap, including improved coupling of coastal, ocean, estuarine and river flow models, all of which really involve multidisciplinary and transdisciplinary work.

One of the key drivers we're counting on to make this progress happen will be NOAA's new **National Water Center,** opening in Tuscaloosa this coming May. This new facility will be a ***focal point*** for changing the way NOAA and the nation tackle these challenges.

Multiple agencies are locating water experts at this facility--the U.S. Geological Survey, the Army Corps of Engineers, FEMA and others, and of course right there with us, the University of Alabama along with other academics. This will be an ***incubator/testbed environment*** in which researchers, forecasters, managers, system operators, work side-by-side and learn from each other rapidly. A test-bed for new modeling and computational techniques.

This is the kind of ***technological and human arrangement*** that accelerates the research cycle and expedites the transition of research and data to operations, applications and societal impact.

I say that with great confidence because we see it in action at other such testbeds across NOAA. Perhaps the most celebrated of which is our Hazardous Weather Testbed in Oklahoma, where our National Severe Storms Lab, our National Storm Prediction Center, our weather forecast office and our new university partners are co-located.

And I'm confident the National Water Center will deliver the same kind of benefits. This is exactly what is needed to change the water equation by providing greater foresight to decision makers that can lead to wiser infrastructure investments and better water management decisions.

Ocean sciences: Beyond the stock assessment to the ecosystem

On the ocean front, JoAnn Simpson, a globally respected meteorologist, once said, “You’ll never really transform fisheries management until you can be as predictive in the fisheries domain as you are in the weather domain. It’s all retrospective. It’s all making the next guess on catch based on statistics of the past catch.” She said that many decades ago.

She was right then, and her point is even more salient today, when the ocean is under stress from many more factors than just fishing pressure: rising temperature and increasing acidity, nutrient overload, pollution, and so on.

That’s why we are working across NOAA to bring to fisheries – indeed to marine ecosystems – the caliber of modeling that exists in the weather and climate arena.

This is a really difficult challenge. Progress here will require rigorous monitoring, process studies and modeling that open the door to better projections of regional climate and ocean productivity predictions and projections on time scales from seasonal to multi-decadal. It will require better understanding of the mechanistic linkages between climate and fish stock fluctuations and change. Most climate change impacts on commercial species revolve around temperature impacts. We need to improve and link our understanding of the synergistic interplay of additional factors, such as pH, bottoms-up forcing, top-down forcing, changing species interactions, and so on.

And we need to learn how to incorporate all of that effectively into management frameworks. In other words, to combine advances in the physical and biological sciences with commensurate advances in the social sciences. (There’s an out of box idea for AGU!)

We've boosted our ecosystem modeling efforts at NOAA and are doing some unusual things, like actually putting our best marine ecologists and climate modelers in the same room. This is already producing some encouraging progress. I'll give you two examples.

NOAA's Charlie Stock and his colleagues at our Geophysical Fluid Dynamics Lab have found recently that Earth-system models project climate change will lead to a decline of one to 10 percent in global ocean **primary productivity** by the end of the 21st century, under high carbon emission scenarios envisioned by the IPCC. This is because projected increases in ocean stratification under global warming will hinder the supply of deep-ocean nutrients to the well-lit ocean surface.

But, as the bottom panels on this graphic illustrate, their work also shows that changes in the production of **large zooplankton** may be twice as large as those for phytoplankton. These changes raise the prospect for very significant regional redistribution of marine resources, which, of course, have implications for regional economies and food security.

The bottom panels on this slide show the analogous quantities for mesoplankton production, which is zooplankton in the ~0.2 millimeters to 2 cm range, including many species of copepods and krill that are critical food supplies for hydrotropic level species. On average, the percentage change in mesoplankton is twice as large as the projected change in primary production.

The "amplification" of this ocean productivity change at higher trophic levels comes from changes in consumer-prey interactions that control the flow of energy from phytoplankton through to the hydrotropic fish.

In another study, GFDL's Vince Saba is working with scientists at our North East Fisheries Science Center to model potential future conditions in the major fishing grounds of the New England continental shelf and slope. As this slide indicates, and particularly the panels in the right hand column, they are applying GFDL's high-resolution climate model to explore at finer, fisheries-appropriate scales the temperature and salinity regimes that can be expected under various IPCC CO2 scenarios. This is RCPA point-5, I think. These new climate change projections will now be used by the

NEFSC and the New England council to factor their projections and future management considerations.

<u>Making It Matter: Weaving Social and Physical Science</u>

The next challenge, or as I always call it, Making it Matter, boils down to weaving the social and physical sciences. In NOAA's world, putting out the most perfect model, forecast or map is something that is **<u>necessary but not at all sufficient</u>**. What really counts is that people act wisely upon the information, to the benefit of their family, town or business. We've always known this, but the point was driven home again forcefully a few years ago.

In 2011, the country was hit in April and May with two massive, record-breaking tornado outbreaks. One hit Tuscaloosa, Alabama, and one hit Joplin, Missouri. Hundreds of tornadoes in each outbreak and hundreds of casualties in each outbreak.

Our post-event service assessment told us that technically and scientifically, the forecasts and warnings had been spot-on and timely, from four days out.

The bulls-eye of our convective risk maps was right where the tornado outbreaks happened, and the tornado warning lead times were above the national average. Yet, hundreds of people died. The science and the forecast were A-plus. The outcome was anything but.

So we convened a town hall with some 500 weather enterprise partners from across the country – atmospheric scientists, forecasters, broadcasters, emergency managers and social scientists. In short, anyone who touches the impact of weather forecasting and warnings on the public – to figure out what needs to be done to change that outcome.

I can tell you I went to that meeting truly expecting to hear that better instrumentation or an improvement in modeling was really the lynchpin, what we needed most.

What I heard instead was that the missing link was in communicating effectively. The missing link, the last link between the scientific forecast enterprise and the public it is charged with protecting. I learned a lot about what we DON'T know about the events that occur after our forecasters hit SEND on a warning, or after a TV broadcaster passes that warning along.

We don't know very much about who acts, and why and how fast. We don't know what drives that, or whether some other form or mode of communication would increase the likelihood of rapid action.

This is a social science challenge, with dimensions in risk perception and behavior, decision science and communications.

And it became clear to me in that town hall that we can no longer develop the physical sciences research agenda or any research agenda to tackle this challenge by laying out the physical sciences agenda first and then inviting a few communications experts, someone else, to come on and bolt on or slap on some social science. The disciplines must be woven together from the formulation of the research questions throughout research design and execution.

That's an atmospheric sciences example, but we face similar challenges with ocean science and resources.

For example, another recent NOAA study found that Alaska fisheries are particularly vulnerable to the effects of ocean acidification.

Red king and tanner crab, in particular, target species in two important Alaskan fisheries, grow more slowly and don't survive as well in more acidic waters.

Our researchers used computer models to predict how rising CO2 levels would affect the ph of the ocean around these fishing grounds. In parallel, the social scientists team assigned scores to the commercial or nutritional importance of each species to 29 discrete regions around the state of Alaska, ranking the areas qualitatively by their reliance on affected species and their ability to adapt to the loss or decline of that species.

What’s the takeaway? Southwest and southeast regions around the Gulf of Alaska are likely to be hit particularly hard by increasing ocean acidification, but each for very different reasons.

Southeast Alaska is a hub for commercial fisheries. Communities there derive the lion’s share of their economic revenue directly from that industry, and so face significant economic consequences from ocean acidification.

In Southwest Alaska, in contrast, subsistence communities predominate. The proximate threat for this region is a fundamental food security threat. If you take the fish away, in frozen southwest Alaska, they can’t just pop down to the grocery store and buy chicken or beef, and that’s because there is no grocery store, or it’s too far away to be practical except on a periodic monthly basis. And in almost all cases, it’s prohibitively expensive for people living in subsistence economies. Roughly 17 percent of Alaskans rely on subsistence fisheries for most, if not all of their dietary protein.

So this is an example that shows that by examining all the factors that contribute to risk, more opportunities can be found to understand the leverage points and hopefully ease or prevent harm to human communities at a local level.
Decision-makers can then address the socio-economic factors that lower the ability, lessen the ability of people and communities to adapt to these coming environmental changes.

<u>Changing the calculus of coastal development</u>

The next one--how do we change the calculus of coastal development, or can we change the calculus of coastal development. I talked earlier about how “green” infrastructure – nature’s own defenses – can and should play a greater role in building coastal resilience. Why isn’t this strategy used more widely already? There are undoubtedly many contributing factors, but I think two are especially significant. One represents a significant social science challenge and the other a physical sciences and engineering challenge.

The social science need – and I would argue the biggest factor that keeps green infrastructure out of the equation – is the lack of methods to assign value to the ecosystem services. Economics is, of course, the primary driver of coastal development, protection and rebuilding decisions. Until we have the means to assign value to the total set of services that natural ecosystems provide us, we will continue to omit these from the balance sheet – on both the cost and benefit sides of the ledger.

The Department of Commerce's Chief Economist and NOAA's own Chief Economist are very much engaged on this topic, with many partners from the academic and NGO communities.

We're also working with the reinsurance industry, which is quite interested in solving this problem so that they can include this in their risk calculations and evaluate the relative cost and protective benefit of natural versus man-made infrastructure.

And that brings me to the physical sciences dimension of this challenge: How do we characterize the protective benefits of various natural ecosystems? Can sand dunes or marshland dunes provide the same protection as a mile of sea wall? Under what conditions? Some work has been done on questions such as these--I saw some of that work at China Camp State Park just yesterday--but not enough yet to change the calculus of coastal development. NOAA's tackling this question with the National Science Foundation and a number of academic partners.

Closing the valley of death

And then finally, the problem that we call "Closing the valley of death." As we sit here today, we in the United States have some wonderfully, incredible examples of earth science that could improve social, economic, and ecological outcomes. Now, more than ever, communities, businesses, government at all levels, and all nations around the world need this science, turned into Environmental Intelligence, to help them build resilience.

But this valuable science can only do that if it's transformed that way, tailored to communities; to the questions facing real people every day in the real world.

The National Climate Assessment is one example of how we're doing this on a nationwide scale. This is regionally based environmental intelligence about current and potential future impacts of climate change. It provides the guidance that communities need to prepare for and adapt to climate change and ocean acidification. This assessment process embraces stakeholders from communities who know in great detail just what their communities need and how they can best use the assessment. And because the science tells us that we need to plan for the near-term and the long-term simultaneously, we transform the assessment process from an episodic thing to a sustained process.

This example of the National Climate Assessment is fundamentally about outcomes. We are improving the impact of research advances on communities by doing a better job of moving knowledge and results from research to operations or applications.

But R2O, as we call it, is a significant barrier to this transformation, and this is a science policy problem we need to tackle across the federal family.

We can do so by identifying and putting into place mechanisms for taking a product off the basic research shelves and refining it for practical uses.

The current state of tsunami detection, warning, and community readiness are pretty timely examples of successful R2O.

Ten years ago December 26, the Indian Ocean tsunami hit. Prior to that event, the world had only 6 Deep-ocean Assessment and Reporting of Tsunami or DART buoys in place. We could predict arrival times, but not flood potential, and not with high precision on an appropriately local or regional scale.

Today – 10 years later – we can tell a different story.

NOAA's DART array is now complete. NOAA operates 39 buoys all over the world, and 21 other buoys are operated internationally by countries that have stepped into the game and provided their own buoys. We can measure tsunamis as small as 1cm in the open ocean and predict when it's going to hit the coast, where it will hit, and how much flooding to anticipate.

We have site-specific, high-resolution community flooding models implemented for 75 U.S. coastal communities.

We operate the only real-time flooding forecast system there is.

And we now have 181 Tsunami-Ready communities in 11 coastal states, including the commonwealths of Northern Mariana Islands and Puerto Rico, and the territories of American Samoa, Guam, and U.S. Virgin Islands. So stop by NOAA's booth to take a look.

Closing

So, in closing, take a look at the image behind me. It bears pointing out that we are the 1st generation of humankind to see Earth this way. Think about that. The space age made it possible for us to measure the entire planet. In effect, to take a snapshot of its condition at virtually a moment in time.

And that has truly transformed our ability to produce environmental intelligence.

We live in an era where insight and foresight about the state of our planet are factored into individual and collective decisions – decisions of tremendous consequence for lives and livelihoods – to an extraordinary degree.

And yet every day, across the entire globe, we see evidence of urgent, unmet needs for the **right science**, at the **right scales**, to reach the **right people** at the **right time** to enable communities to make **wiser decisions** for their future and the future of the planet.

This is the grandest challenge and great calling for any scientist who cares about this planet, who is curious about how it works, who aims to be of service to humanity, who wants their work to really matter.

That’s the passion that looking at the Earth from space ignited in me, and the reason I am so glad and so proud to be at NOAA today.

I can’t think of a better time to be an Earth scientist. I can’t think of more worthy and vital work to do than this work.

Our expertise and our passion to understand this little blue marble we live on are exactly what it takes to meet these urgent needs.

There is great, and challenging, and critically important work to do. YOUR talents and energies are needed desperately. So join us, and speaking of joining us, that announcement I mentioned earlier, would be a very cool way that you could do that.

Our announcement today, on behalf of the White House Office of Science and Technology Policy, is a really cool new open innovation opportunity, a new sensor challenge. And this aims to accelerate the development and production of accurate and affordable nutrient sensors for use in aquatic environments. These next generation sensors are going to have to satisfy three criteria. They’ve got to be easy to use, with maintenance free deployments of three months. Anyone who’s spent time it the ocean knows how much fun that is. They should cost less than $5,000 to purchase and be commercially available by 2017. This challenge comes out of the Coalition on Nutrients Coalition, a collaboration of federal agencies, academia, and private sector partners, that’s been working together to develop a suite of real-time sensors that can measure nutrient volume in bodies of water. The coalition was convened by the White House just a while back, and includes the Environmental Protection Agency, the U.S. Geological Survey, our sister bureau the National Institute of Standards and Technology, and the Alliance for Coastal Technologies, the entity that will coordinating this challenge. I hardly need to give this audience a lecture about how sensors are critically needed.

They're essential for our understanding the quality and function of ecosystems. It's also essential for the protection of human health. Harmful Algal blooms, like the ones we've seen in Lake Erie lately, the one last summer, that severely affected the water supply of metropolitan Toledo, they're more and more commonplace. Every single year, we also see huge dead zones in many bodies of water, most notably the Gulf of Mexico. So help us do this. We need your creativity, your knowhow, to figure out how to do this. The prize-winning sensor needs to meet those three criteria and let's get going on this. If you want some more information, I invite you to talk with Dr. Tammy Dickenson, from OSTP in the White House, who's here with us today, or with Dr. Mario Tamburri from the Alliance for Coastal Technologies, who'll be leading the verification portion of the challenge. The blog site is also live, featuring a post from Dr. Dickenson just yesterday, and you can check it out online at www.nutrients-challenge.org. So I hope we'll see many AGU members and participants among the contestants for this great prize.

So again, take a look at that little black marble. It's a pretty cool place to live on. And it's a fabulous thing to be an earth scientist in this day and age. We need to devote our time to these grand challenges. And we look forward to NOAA to having many of you work with us as we move forward to provide communities with the information they need to become more resilient. Thanks very much.